

D1
N84 20526

MEASUREMENTS IN LIQUID FUEL SPRAYS

Norman Chigier
Department of Mechanical Engineering
Carnegie-Mellon University

The goal of our research on the measurement of liquid fuel sprays is to study the effects of atomizer design and to characterize the atomization and vaporization processes in sprays under well controlled conditions. The scope of this study is limited to the events directly preceding combustion in the liquid fuel sprays. Measurement techniques are being used to provide information as a function of space and time on droplet size, shape, number density, position, angle of flight and velocity. Three spray chambers have been designed and constructed for: (i) air-assist liquid fuel "research" sprays; (ii) high pressure and temperature chamber for pulsed diesel fuel sprays; and (iii) coal-water slurry sprays. Recent results utilizing photography, cinematography, and calibration of the Malvern particle sizer are reported. Systems for simultaneous measurement of velocity and particle size distributions using Laser Doppler Anemometry/Interferometry and the application of holography in liquid fuel sprays are being calibrated.

Parker Hannifin has designed an air assist swirl atomizer for use in basic research studies at several universities (Carnegie-Mellon, Purdue, UC/Irvine). This atomizer has been fitted into the basic research spray chamber in which uniform low turbulence intensity air flows vertically downward. The liquid fuel spray is injected downward along with the uniform air flow. Detailed measurements of the distributions of particle size, particle velocity, and gas velocity will be made throughout the sprays under conditions of well controlled initial and boundary conditions.

Design and construction of the high pressure and high temperature swirl chamber has been completed to withstand maximum pressures of 60 atm. and maximum temperatures of 370°C. Two quartz windows, 89mm in diameter, are fitted to the chamber for optical access. An electromagnetically controlled pulsed diesel injector has been operated with the chamber and preliminary photographic studies have been made. The air-assist swirl atomizer will, at a later stage, be installed in this high pressure chamber.

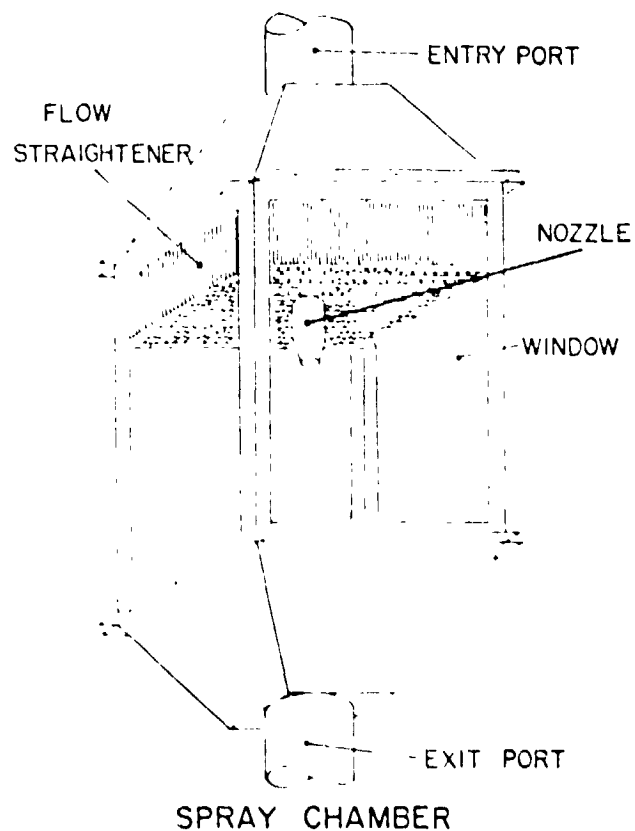
The coal-water slurry spray test facility was operated with a Parker Hannifin counter swirl atomizer to investigate fundamental processes leading to combustion of coal-water slurries. This research is focused on two areas: the vaporization of water and the devolatilization of the coal particles in the spray. Preliminary studies on drop size, shape, and distribution were made using photography, cinematography, and the Malvern particle sizer. High quality images of commercial coal-water (70% to 30% concentration) slurry spray at various atomizing air pressure and slurry feed rate have been made. The magnification of these pictures is 8.4 times lifesize and is about 1 inch distance from the nozzle tip. The spray appeared very dense in the photographs. The smallest particle/droplet size that can be distinguished on the edges of the spray is in the order of 40-50 microns. There is evidence of low-frequency pulsations in the spray in both photographic and high speed cinematographic results.

Samples of diluted coal-water slurry were measured by the Malvern particle

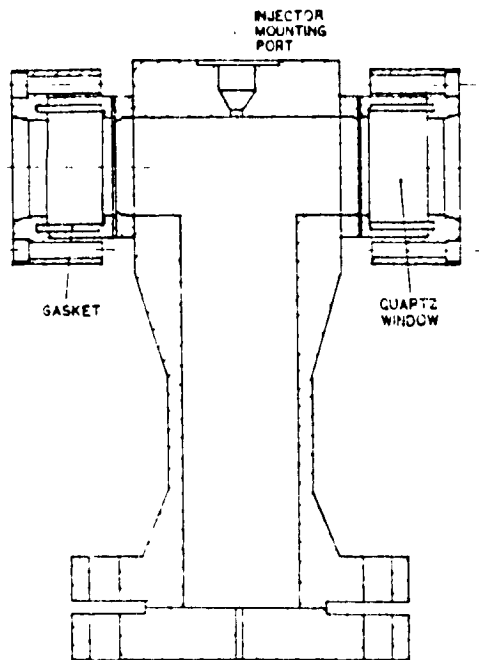
ORIGINAL PAGE IS
OF POOR QUALITY

sizer for size distribution. The results showed that the coal particle SMD fell within the size range of 2 microns to 1.5 microns for an obscuration ranging from 0 to 90 percent.

The behavior of the Malvern 2200 particle sizer was investigated by analyzing a non-varying calibration reticle produced by Laser-Electro optics. Some of the important parameters varied during the experiment were: photomask tilt angle, distance between photomask and receiver lens, and receiver lens focal length. All of these variables proved to be very crucial in the determination of size distribution by the Malvern.



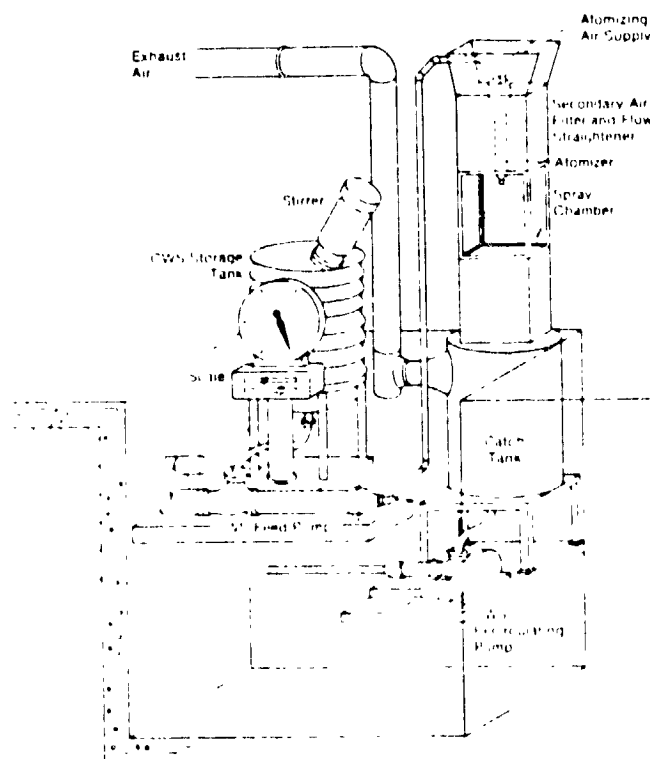
ORIGINAL PAGE IS
OF POOR QUALITY



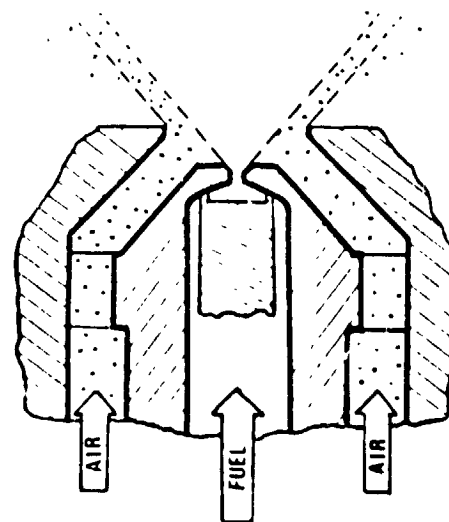
CHAMBER

Max temperature	370°C
Max pressure	60 atm
Diameter	120 mm
Height	460 mm
no of window ports	2
Diameter	89 mm

SPRAY CHAMBER



Three-Dimensional View of the Experimental System
to Study Coal-Water Slurry Sprays



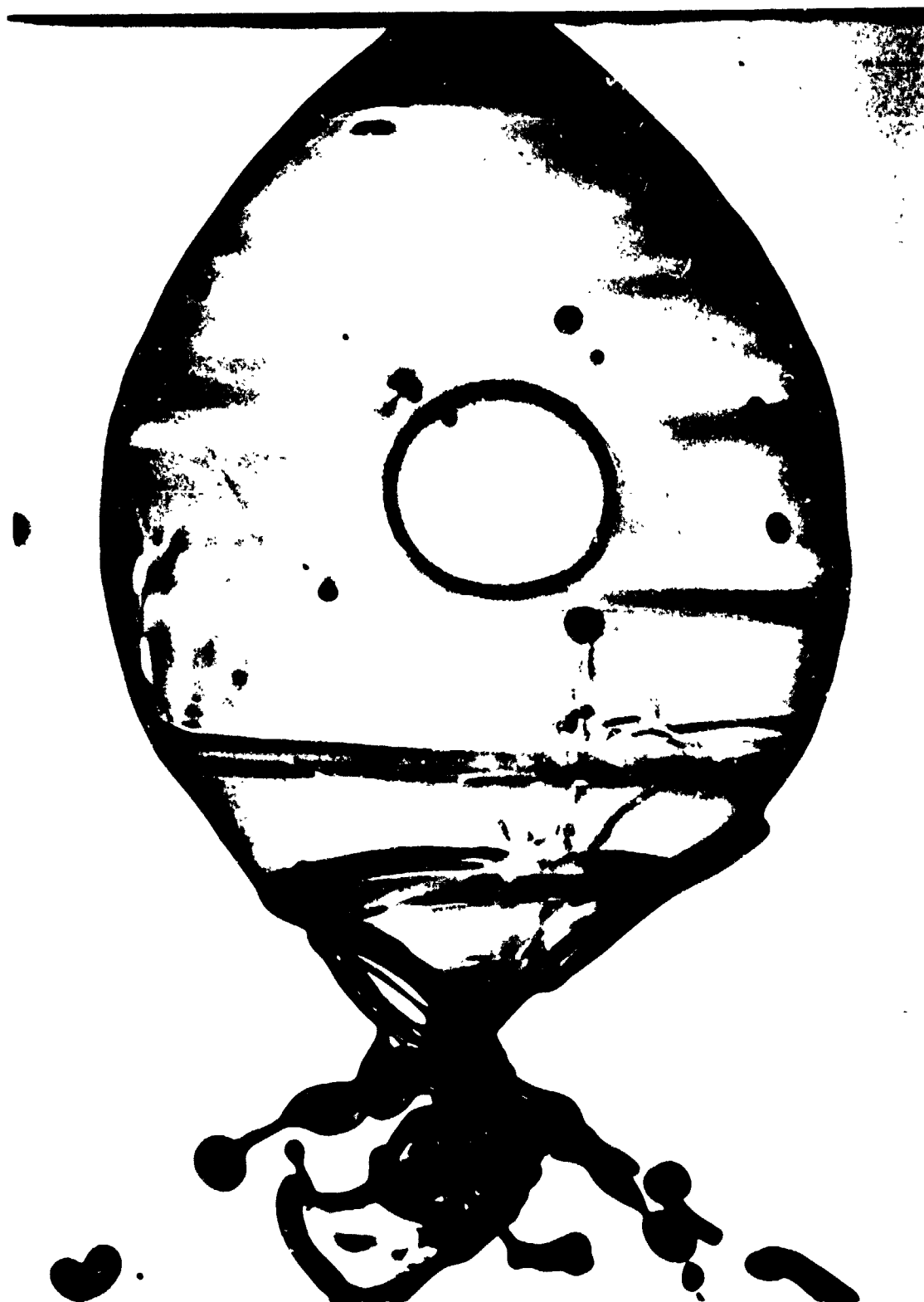
Air Assisted Atomizer

ORIGINAL PAGE IS
OF POOR QUALITY



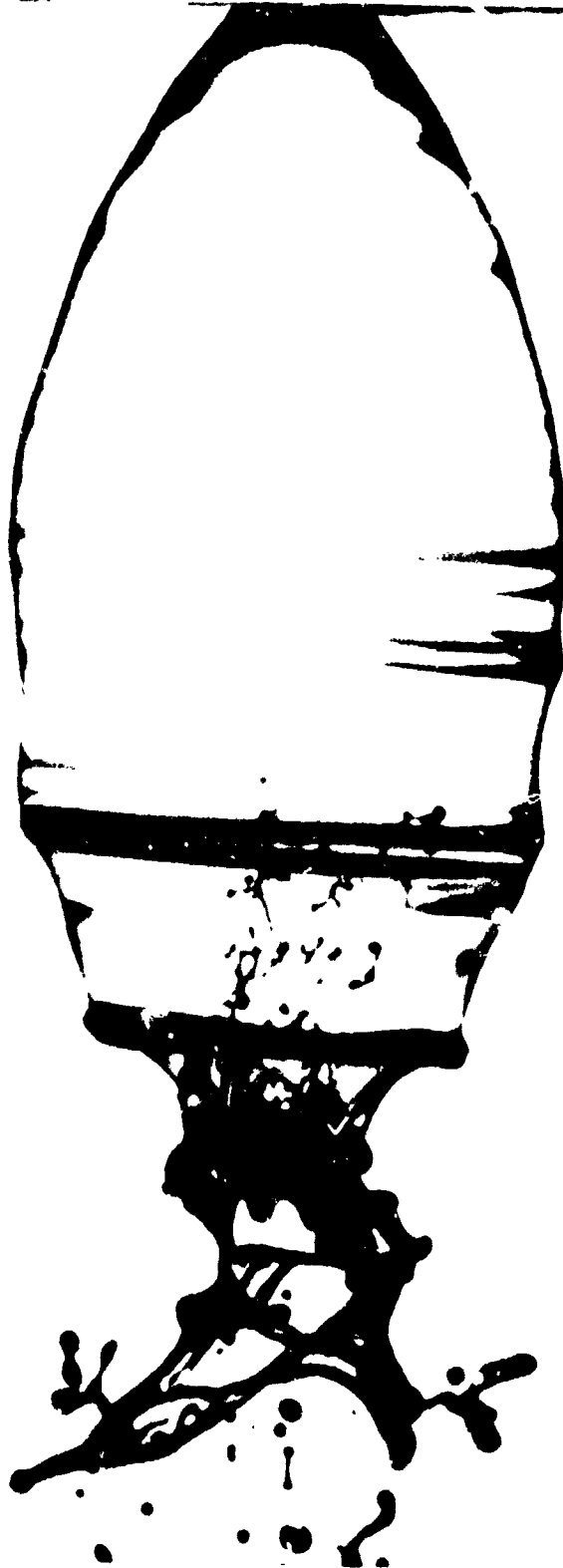
Fuel: 50% Ethylene Glycol, 50% Water by volume.

Fuel pressure: 20 psi, Nozzle: 60 degree solid cone.



Fuel: 50% Ethylene Glycol, 50% Water by volume.

Fuel pressure: 21 psi, Nozzle: 60 degree solid cone.



Fuel: 50% Ethylene Glycol, 50% Water by volume.

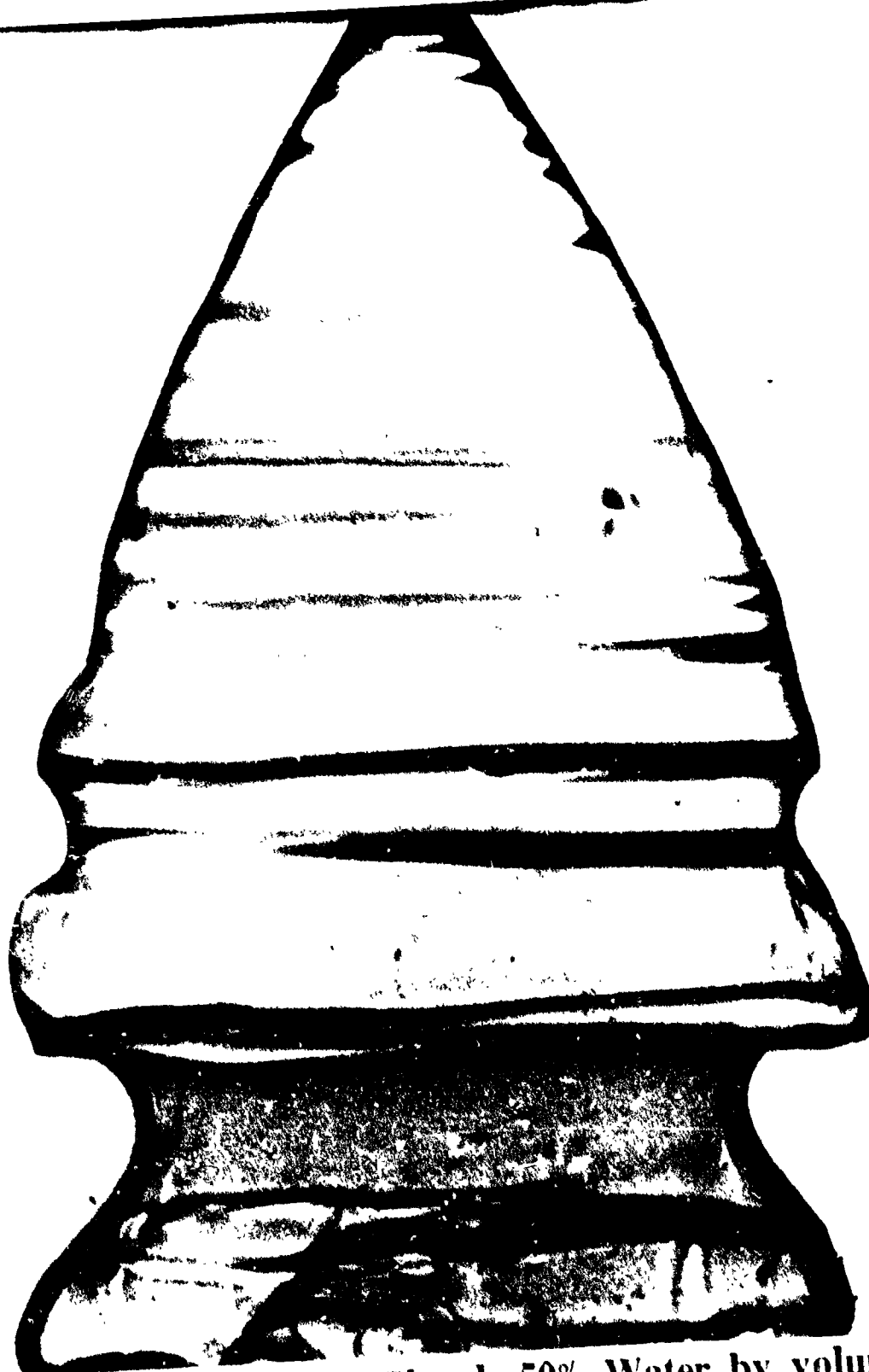
Fuel pressure: 40 psi, Nozzle: 45 degree solid cone.

ORIGINAL PAGE 19
OF POOR QUALITY



Fuel: 50% Ethylene Glycol, 50% Water by volume.

Fuel pressure: 70 psi, Nozzle: 45 degree hollow cone.



Fuel: 50% Ethylene Glycol, 50% Water by volume.

Fuel pressure: 80 psi, Nozzle: 45 degree solid cone.

ORIGINAL PAGE IS
OF POOR QUALITY



Slurry: 210 lb/hr, 22 psi; Air: 44 psi

ORIGINAL PAGE 19
OF POOR QUALITY



Slurry: 360 lb/hr, 42 psi;

Air: 73 psi

EXPERIMENTAL DATA
OF 10-11-57



Slurry: 360 lb/hr, 50 psi;

Air: 132 psi

ORIGINAL PAGE IS
OF POOR QUALITY



Slurry: 500 lb/hr, 48 psi; Air: 45 psi

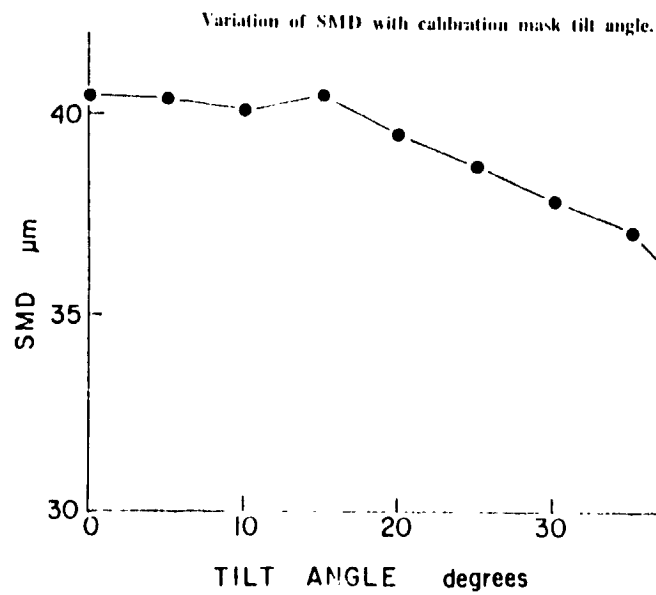
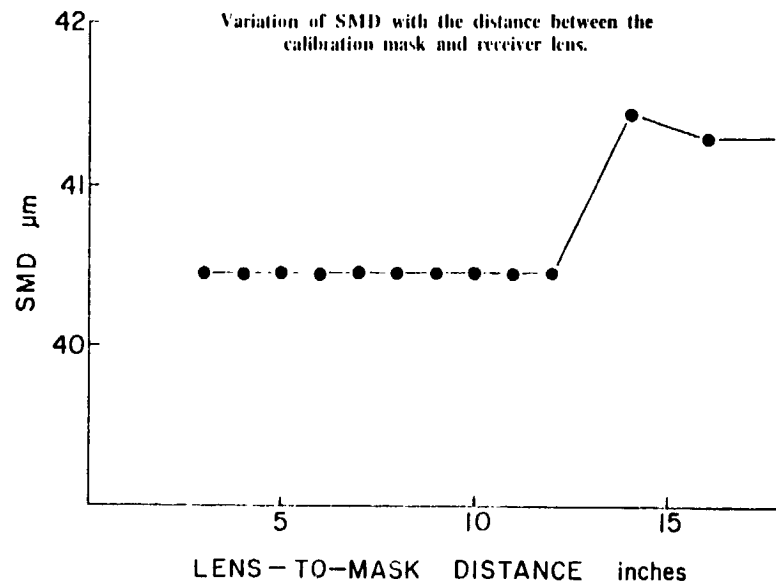
ORIGINAL PAGE IS
OF POOR QUALITY



Slurry: 500 lb/hr, 72 psi;

Air: 162 psi

ORIGINAL PAGE IS
OF POOR QUALITY



ORIGINAL QUALITY OF POOR QUALITY

